Towards the efficient and accurate numerical modelling of extreme short-crested sea states

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The deterministic modelling of directional sea states is highly challenging, especially in the presence of breaking waves. When focusing on the sole wave propagation (i.e. no wind effect), one can either i) model with high-fidelity solvers the problem in all its complexity (viscous fluid, air entrapment, bubbles formation, etc.), which is up-to-now limited to small spatial regions and short durations due to the induced computational effort; or ii) model with medium fidelity solvers the wave propagation using (weakly) nonlinear potential flow solvers, associated with a specific numerical treatment for breaking waves.

In the ocean engineering context that is our final application case, it is of interest to have access to a description over large spatial and temporal scales (O(1 h) and O(100 km^2)). This work will report the latest numerical developments regarding the nonlinear wave propagation of short-crested sea states using the High-Order Spectral (HOS) method. Those developments focus on enhancing the numerical treatment of breaking events in such models. The main objective is to include most of the effects of individual breaking events (energy dissipation and redistribution: amount and frequency content). This should allow having an efficient numerical model able to reproduce the evolution of a directional wave field in extreme conditions with high accuracy.

A methodology has been implemented and validated in HOS solvers for uni-directional sea states [1, 2]. It is here extended to multi-directional wave fields. It involves two steps: the first one is the wave breaking detection, and the second one is the dissipation of energy induced by the detected breaking event. For the wave-breaking onset, the ratio of the fluid velocity and local crest phase speed, $B = U/C$, allows accurate detection of the breaking events. The key point for this kinematic criterion B is the evaluation of the crest phase speed, which is challenging in multidirectional seas. [3] proposed a so-called Spatial Hilbert Transform Method (SHTM) and argued that the SHTM allows an accurate and efficient computation of the local crest phase speed in short-crested sea states. Once the breaking wave is detected, adequate management of the energy dissipated during wave breaking is indispensable and pivotal. The chosen approach is based on the addition of viscous terms to the free surface kinematic and dynamic boundary conditions.

Finally, experiments have been conducted in the large-scale ocean wave tank of École Centrale Nantes (50 m x 30 m x 5 m). Different wave fields have been generated to help validate the developed numerical model. Directional focused waves have been generated with the objective to characterize the dissipation of energy induced during single breaking events, see *e.g.* Figure 1. Then, irregular short-crested sea states have also been generated. Preliminary results regarding those experiments will be presented during the conference.

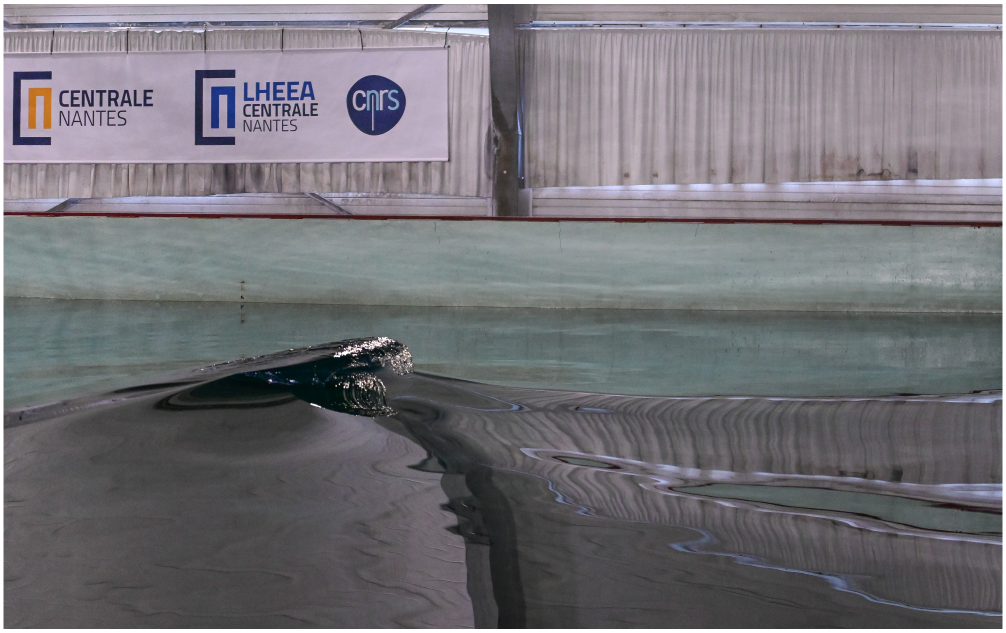

Figure 1: Directional breaking waves.

REFERENCES

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